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STUART DAGGETT
University of California

San Francisco Bay Bridge Studies

and

Rapid Transit Problems

A REPORT TO THE
San Francisco Chamber of Commerce
BY
B. M. RASTALL

RAPID TRANSIT AND TERMINAL PROBLEMS

Engineering talent has been working on the problem of bridge rail travel and the rapid transit terminal for a long period. At the time this study was undertaken, between twenty and thirty different sites had been tentatively suggested and plans filed with the Toll Bridge Authority. This number does not include a large number of amateur plans but only those that had received engineering study.

It is always valuable to seek by analysis to reduce a business problem of this kind to its lowest terms—to get a clear picture of what is the objective. Always when such a clear cut objective is stated, the solution becomes much simpler.

Fundamentals: Convenience and Cost

"Why then are we building the Bay Bridge? For what purpose does it exist?" Is not the complete answer "For the greater convenience of the traveling public?" Certainly if the truck driver is included as a traveler so that the freight problem is included, this is a complete answer. We are building the bridge solely to create more convenient travel between communities. This convenience is gained in two ways (1) by shorter time of transit; (2) by greater comfort of travel, including avoidance of crowding. What is true of the Bridge must also be true of the terminals which are part of it. If the Terminal is so located that travel time gained in crossing is lost for the average traveler by landing him further from his work, there is no net gain; or if he is landed so as to have to fight his way thru a congested area, both the time and comfort gained will be lost.

But the convenience in this case must be secured at low construction cost. The bridge is being built on borrowed money and stringent limitations are being imposed by the Federal authority—only that amount will be loaned which the rail revenue definitely in sight will repay. Large ncreases in fares cannot be used to justify a large loan because they would cut down travel and hurt rather than help probable net income. A strict imitation is thus put upon terminal costs.

Unfortunately, the cost and convenience factors work against each other. Sites that serve convenience perfectly are likely to be too expensive and those of lowest cost to be at very inconvenint locations. This is actually he rock on which most of the terminal plans have foundered. The Bridge nd railroad engineers, without much training in the economic viewpoint, have been inclined to subordinate convenience and work solely for the lowst costs, while the committees of civic bodies, not having the responsibility of financing the bridge, have demanded the utmost convenience regardless of cost.

On recognition of the fundamental necessity of balance between conenience and cost the terminal problem narrows down to a small range of ites. Let us see what can be done to further narrow the search by elimiation.

By Elimination

The running of bridge trains into any kind of nearby subway is impossible because of the great drop from the bridge elevation, with resulting rades much too heavy for rail travel. Surface locations are practically out lso, for the same reason and the added necessity of giving first-class street car loop connections, a situation which can be adequately handled for both space and convenience only with the bridge trains coming into an elevated rminal and street car loops placed immediately underneath.

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The most rapid and convenient rail service across the bridge can unquestionably be provided by running the trains of the Southern Pacific and Key Route systems directly without "change," to a San Francisco terminal. In our process of elimination it is assumed, therefore, that the negotiations between the Bridge Authority and the railroads will be successful in working out this direct service. The alternatives should be considered only if these negotiations finally break down.

As to location, the area between New Montgomery and Fifth streets is put out of consideration because of the high stage of congestion already present on Market street through that section. If the huge mass of travel now coming through the Ferry Building were to be dropped close to Market street in that area, seeking as it must Market street crossing, the most congested street situation in all America would result, and the advantages of bridge travel for the train passenger largely nullified. Sites above Market street, while they would serve a large number of passengers conveniently, are impossible because of the high costs of running into and providing adequate station space in that district of high realty values. To amortize the costs, rail fares across the bridge would have to be raised to an impossible amount.

Our search, therefore, narrows down to the best elevated site, combining convenience with low cost, located south of Market street and below New Montgomery street. This site to best serve convenience must combine nearness to Market street, first-class street car connections and special facilities for crossing Market street.

The Best Site

An intensive search has been made to discover the site best covering these features and in the section indicated. This appears to have been found as indicated on the map (page 18), between First and Second streets from Mission to Minna streets. This space is as close as it is safe to come to the congested area and is as close to Market street as can be had without excessive land costs. Moreover, it is possible from this site to run two wide elevated sidewalks across Market street and thus eliminate the crossing problem almost entirely for pedestrians. Ecker street runs from the foot of Sutter street across to Mission street, and Anthony street runs most of the way across shortly above that point. Anthony street can be continued to Market street by the purchase of two small buildings and a narrow strip of land. These two streets would be used for the elevated sidewalks.

Still following the map, it will be noted that the Sutter street car line can be brought directly across Market and thru Ecker to the terminal. Ecker will need to be widened somewhat for about 150 feet to accommodate two street car tracks. Anthony street has plenty of capacity for two tracks and whatever cars the two street car companies conclude to send thru the terminal can be amply handled by these two streets which, of course, would be closed for other traffic except at "off" hours. A further improvement can be made by running the Geary cars directly across Market and thru Annie to Mission, and then down Mission to the Terminal. The problem of street car congestion would be greatly improved by thus taking several lines of cars off Market street and by utilizing special loop streets to keep street car travel largely off First and Second streets.

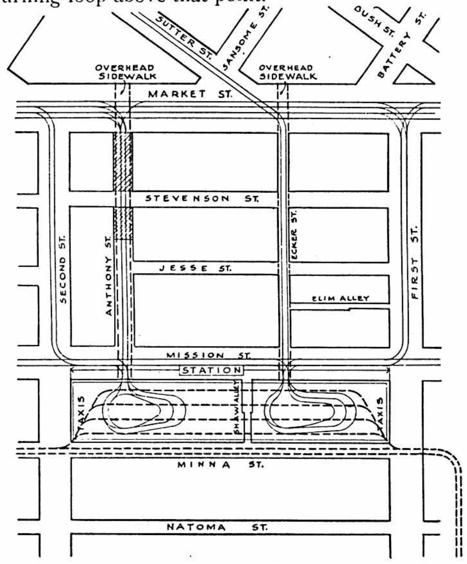
The above site has been studied carefully by the Bridge engineers, who agree as to its desirability but who feel that the relatively high cost of property on Mission street and the substantial buildings to be destroyed put this site beyond the price which they can pay. They have selected a site only half a block from this location and while the facilities are not so good for elevated sidewalks or street car loop, it appears that the cost limitations must prevail.

No Single Terminal Adequate

The site indicated for the San Francisco rail terminal is practicable so far as any single station can be. It is near Market street, avoids the highly congested area, gives opportunity for direct street car connecting loops, and gets pedestrians across Market street on elevated sidewalks.

However, no single terminal station can give adequate convenience for the entire East Bay travel. This results from two features—(1) the large volume of this travel at peak hours, such that congestion will be caused if it is dumped at one spot, even outside the congested district; (2) the wide spread of destinations in this travel stream.

A study of San Francisco destinations (see graph page 24) by small districts, shows that roughly one-half the passenger travel is to and from points above a line drawn through Fourth street. This does not mean that fully half the travel would be better served by a station at Fifth or Sixth streets, because of the peculiar features of street car routes. However, allowing fully for this factor, it appears that about one-third the total number would be better served at that point. The question arises, therefore, why not a two-station terminal? As a great added convenience to the traveling public, both in avoiding delays and discomfort from crowding, and in reaching more closely to destination points, such a terminal can be very strongly urged. It could be built without great additional cost by running the elevated line up Minna street to a station at Fifth or Sixth street and providing a turning loop above that point.



PROPOSED TERMINAL STATION

Rapid Transit

The Bridge Authority having studied this idea, does not believe that it can borrow sufficient money to build the additional trackage, loop and station, and that the Railroad would refuse to operate over them because of increased costs.

This does not settle the problem but simply opens it to wider inquiry. Even a two-station terminal would be quite inadequate for the proper distribution of bridge travel. For most convenient use of the bridge, as large a rapid transit system is required in San Francisco as in the East Bay section giving direct access to each principal district. It can hardly be the function of the Bridge to build such a system. The problem is to San Francisco transportation interests, adding another motive for thorough study of the rapid transit problem. We have already seen that badly needed relief of Market street; the necessity for assuring balanced development; and slow, crowded, service to western and southern suburbs combine to point the immediate necessity for rapid transit relief. If this rapid transit system can be made to serve the bridge also, giving as extensive a service on this side as in the East Bay another important objective will be reached.

But can a rapid transit system be found which will solve all these problems and at the same time be sufficiently inexpensive to build and operate without involving great increase in fares? Diligent search has been made for the routing and layout of such a system and two reasonable answers have been found.

The first solution is in a combination surface-elevated line so located as to take traffic *from* and feed *to* the Bay Bridge: also to handle business from the congested area along Market street; the Mission district; the whole western area via Twin Peaks and Sunset tunnels and the southern area via the Southern Pacific system.

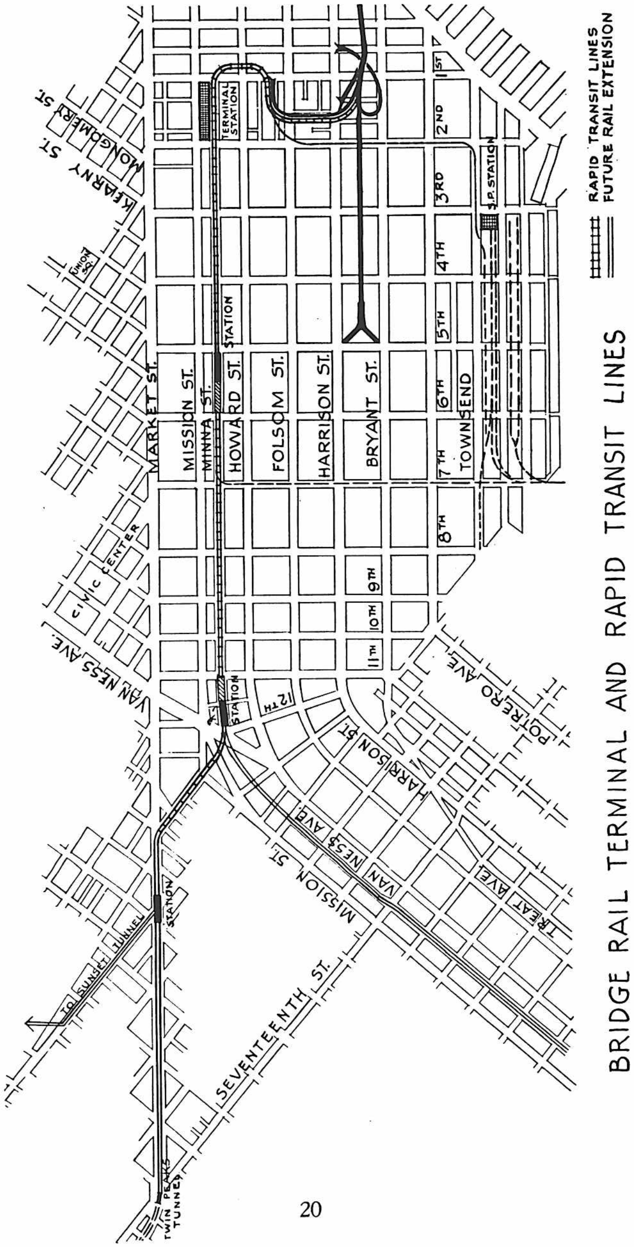
Minna Street Elevated

From the Bridge Terminal at Second street, the rapid transit elevated lines would continue up Minna street with stations at Fifth or Sixth and at Eleventh or Twelfth streets. This would give two stations on the edges of the congested district. The Fifth Street Station would serve a mesh of street car lines on Fourth, Fifth and Sixth streets, and Howard, Mission and Market streets. The Eleventh Street Station would serve Van Ness Avenue, upper Market and the Mission district, with street car transfers to that section.

At Twelfth street, the line would cut across two short sections of private property—about half a block with only the cheapest sort of improvements. It would then run up McCoppin street to Market. McCoppin strikes Market on a sharp hill so that the lines could be brought to the surface at that point with practically no grade.

Twin Peaks Tunnel

The present surface lines would be used along upper Market street and thru the Twin Peaks Tunnel, a bore admirably adapted to rapid transit service. A small plaza station would be placed at West Portal. The street



BRIDGE RAIL TERMINAL AND RAPID TRANSIT LINES

car lines west of Twin Peaks would operate to this plaza, transferring their load to the rapid transit line. A stop would be made at Duboce Avenue for a similar transfer of Sunset Tunnel passengers.

A Five Mile System

This would give a combination surface, elevated, subway line of five miles, requiring construction of only 1.8 miles of elevated structure. It would give the Bay Bridge a three-station terminal reaching the whole downtown district at convenient points as well as the Mission and western districts. An inexpensive rapid transit system would be provided, badly needed now to relieve Market street and giving (1) distribution to the Bay Bridge rail traffic, profitable to San Francisco, both in income and city development; (2) better street car connections generally, with smaller total transit times; (3) modern rapid transit for which the Twin Peaks Tunnels are fitted; (4) more rapid and convenient service to the Richmond and Sunset areas; (5) improved travel to the Mission district and (6) opening the whole southern and Peninsula areas to modern rapid transit development.

Distances on this rapid transit line would be as follows: (distances furnished by office of the City Engineer). Total length of Twin Peaks Tunnel 12,000 ft.=2.3 miles; From East Portal to McCoppin street 4,650 ft.=0.9 miles; from corner Market and McCoppin to Minna and Twelfth streets, 1,930 ft. and from that point to First and Minna streets, 7,440 ft. or total length of elevated line 9,370 ft.=1.8 miles; total length of system from West Portal to First Street Terminal—5 miles.

Fast Time

Operating time over this system with modern fast equipment is estimated as follows: Twin Peaks Tunnel 2.5 miles at 45 miles per hour, 3 minutes; surface operation on Market street to McCoppin, 0.9 miles at 25 miles per hour, 2.2 minutes; elevated line 1.8 miles at 45 per miles per hour, 2.4 minutes. Assuming that stops must be continued at the stations inside the Tunnel, there would be five station stops between the terminals. Adding one minute each for these stops and regaining speed, the total operating time—terminal to terminal—would be 12.6 minutes.

The new subways in New York, with fast loading equipment are now making an average stop of twenty seconds for loading and taking twenty seconds for additional speed losses; we are thus allowing the San Francisco system substantially in excess of requirements. This would make the round trip, with substantial terminal stops, in thirty minutes. For slower speed operation, if that appears desirable, the time through the tunnel and over the elevated line can be figured at thirty-five miles per hour, and on upper Market street at twenty miles per hour when the run from West Portal to First street would be made in approximately 15½ minutes, including one minute for each stop. The round trip would be made in thirty-five minutes.

A Subway and Rapid Transit System . . .

for San Francisco

Report to Mayor Elmer E. Robinson
by Paul Oppermann, Director of Planning
APRIL 1950
San Francisco Department of City Planning

Including report to City Planning Commission
By DeLeuw, Cather and Company . . .

SUBWAY AND RAPID TRANSIT SYSTEM

SUBWAY
FIRST STAGE

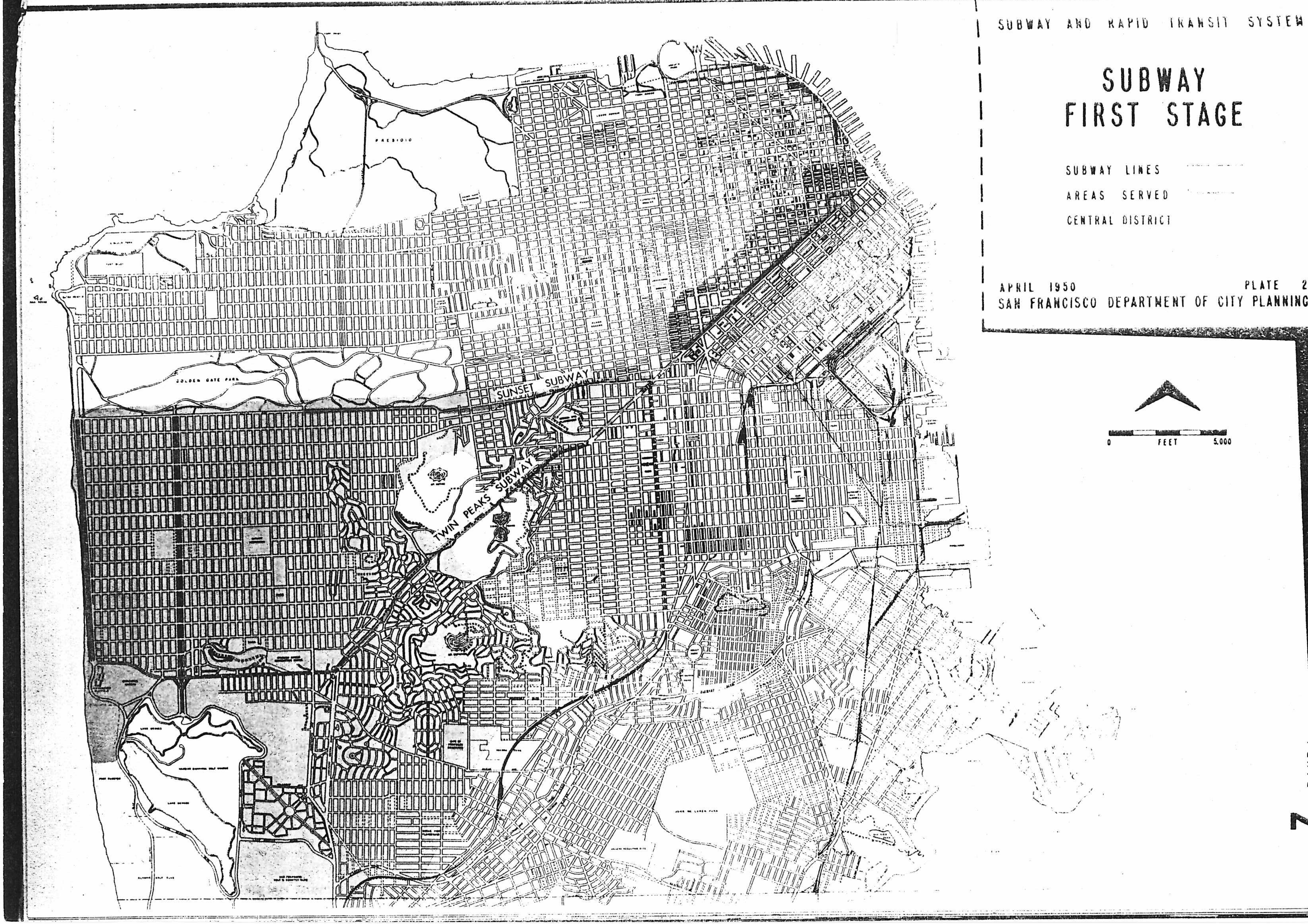
SUBWAY LINES

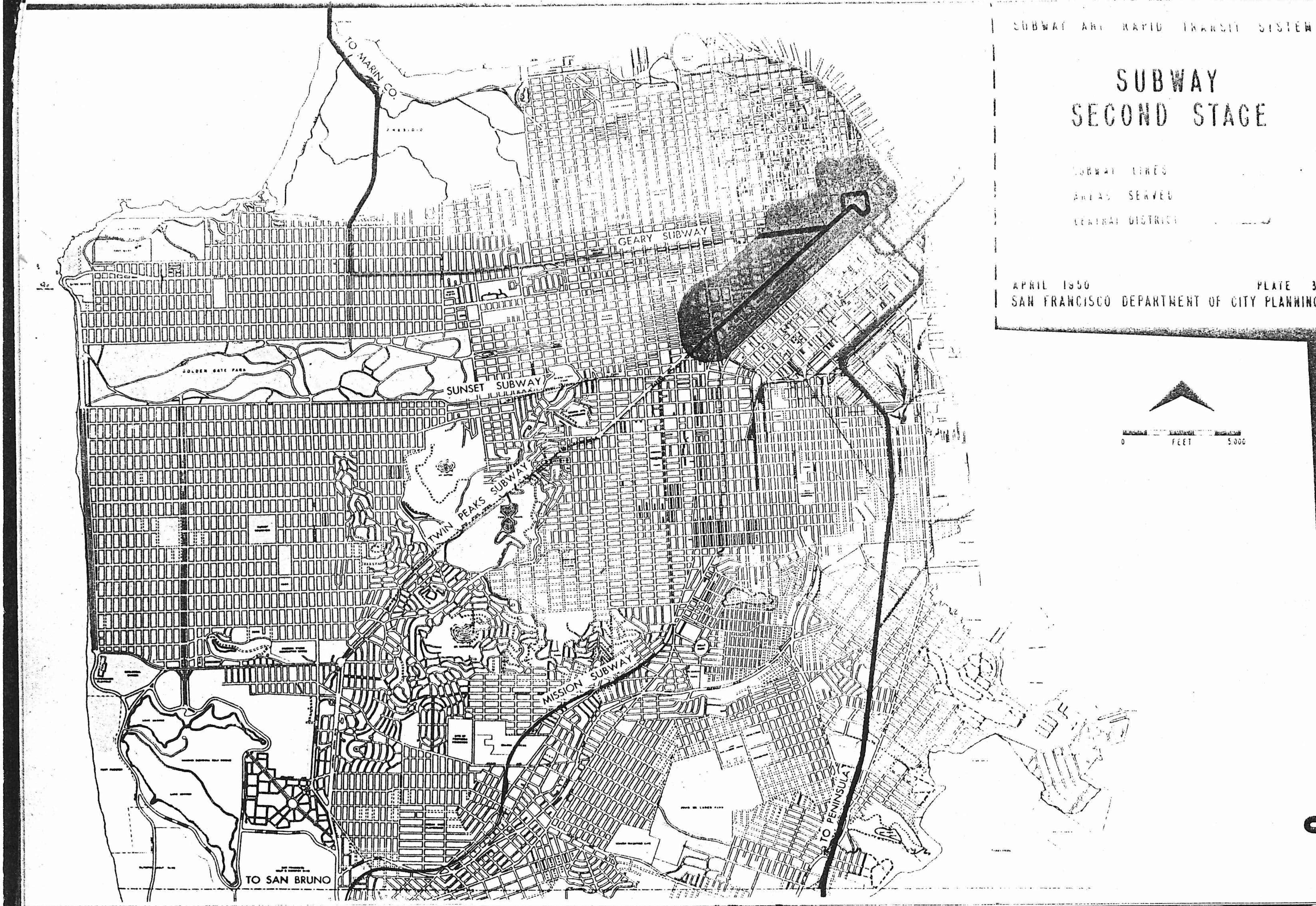
AREAS SERVED

CENTRAL DISTRICT

APRIL 1950 PLATE 2

SAN FRANCISCO DEPARTMENT OF CITY PLANNING





SUBWAY AND RAPID TRANSIT SYSTEM

SUBWAY SECOND STAGE

SUBWAY LINES
AREAS SERVED
CENTRAL DISTRICT

APRIL 1950 PLATE 3
SAN FRANCISCO DEPARTMENT OF CITY PLANNING

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AN ANALYSIS
OF THE
REPORT OF
PARSONS, BRINCKERHOFF, HALL AND MACDONALD,
ENGINEERS
TO THE
SAN FRANCISCO BAY AREA
RAPID TRANSIT COMMISSION

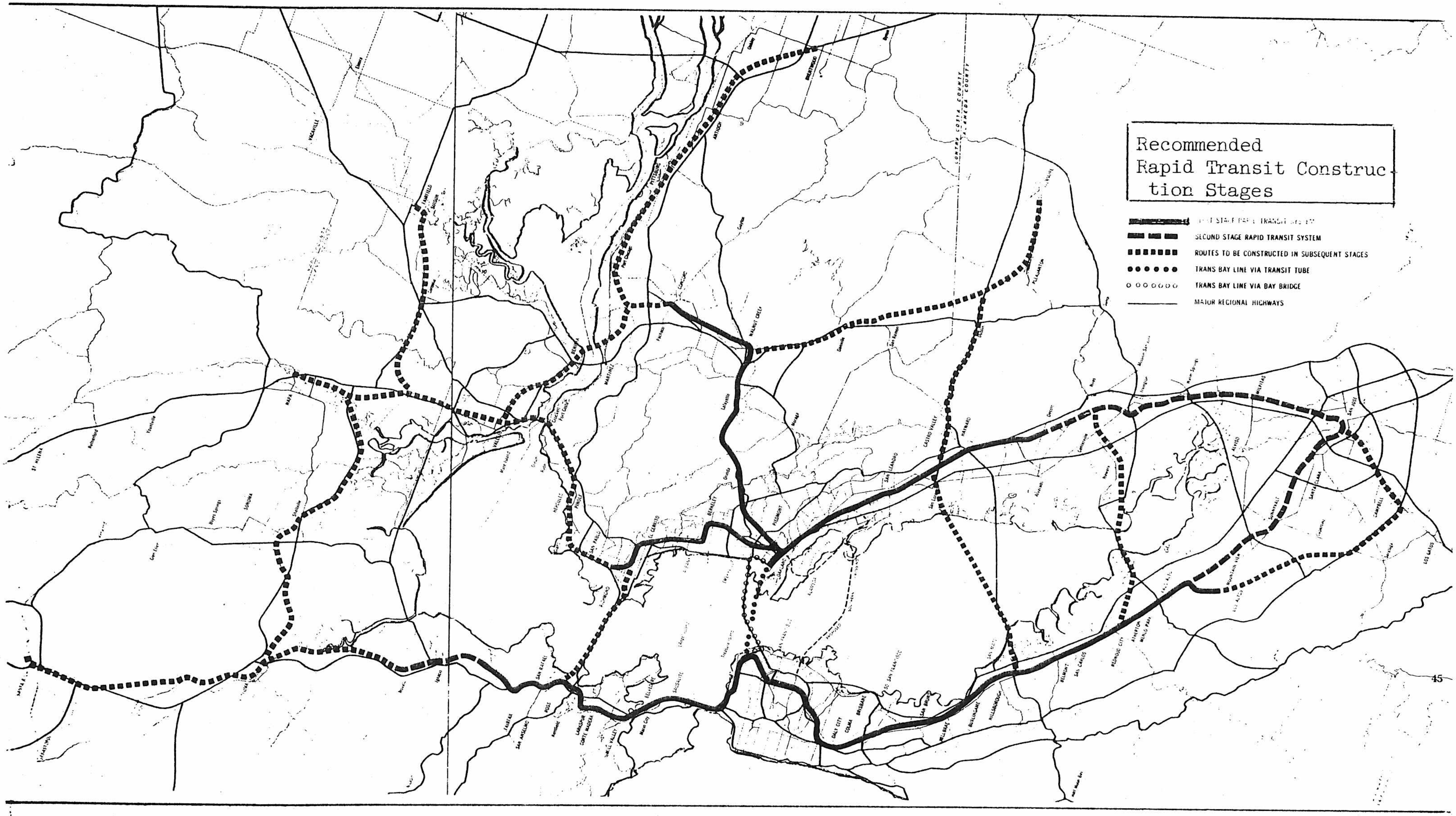
Prepared By

HENRY K. NORTON

For

THE SAN FRANCISCO BAY AREA COUNCIL
130 Montgomery Street
SAN FRANCISCO, CALIFORNIA

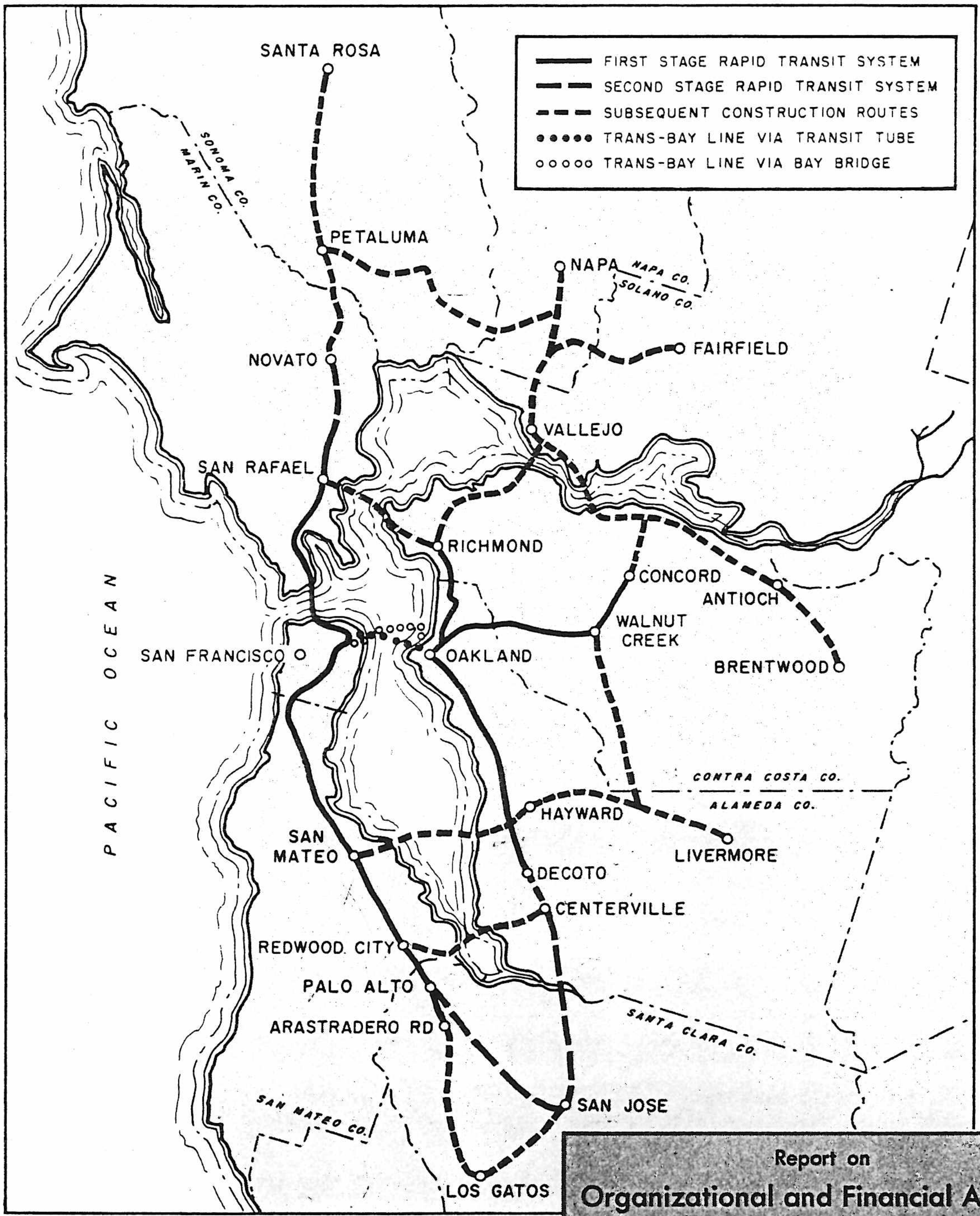
February 1956



Recommended Rapid Transit Construction Stages

SAN FRANCISCO BAY AREA

RAPID TRANSIT COMMISSION



Report on

Organizational and Financial Aspects of a Proposed Rapid Transit System

for the

San Francisco Bay Area

MARCH 1956

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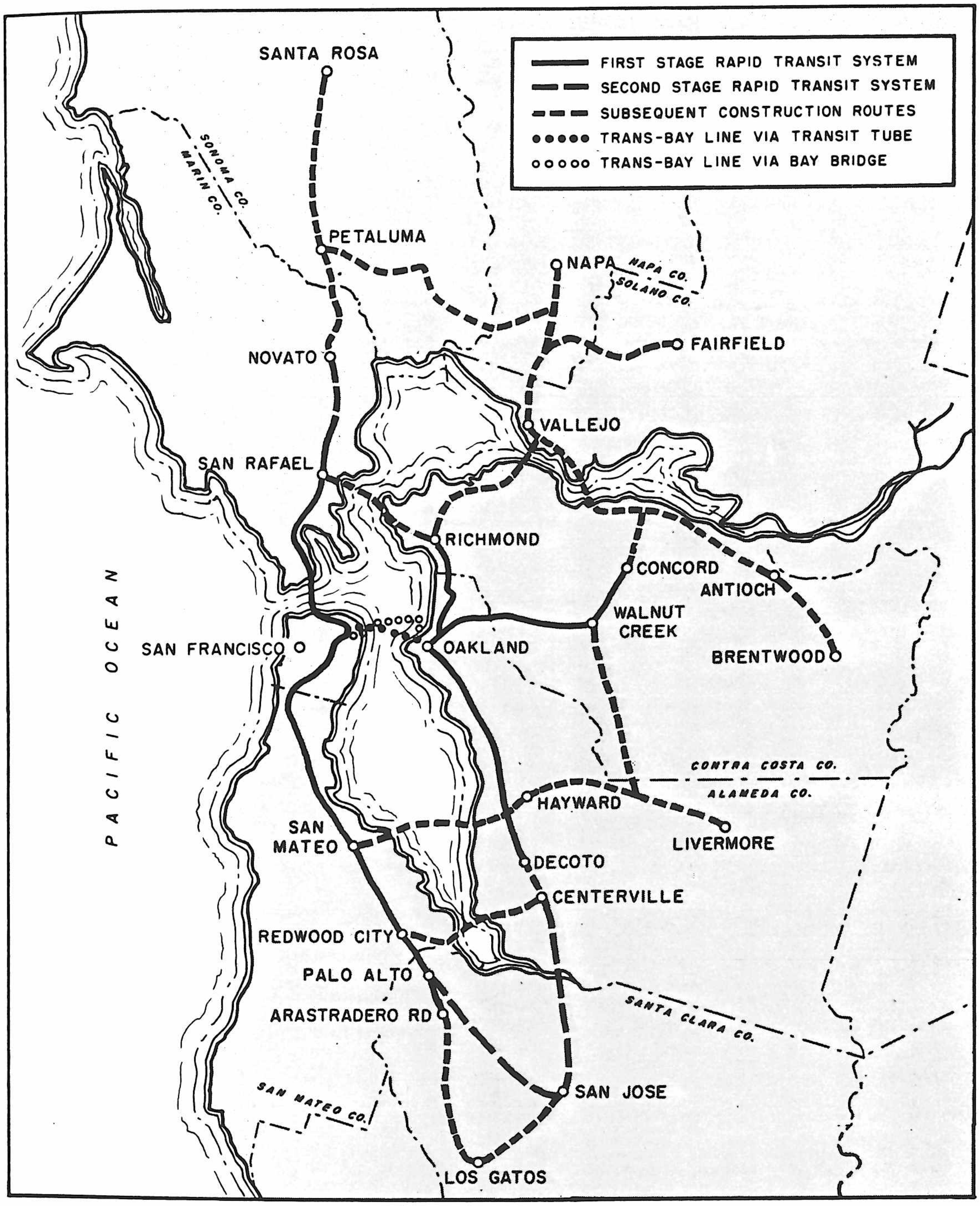

Report to the

LEGISLATURE OF THE STATE OF CALIFORNIA

DECEMBER, 1957

SAN FRANCISCO
BAY AREA RAPID TRANSIT DISTRICT

SUPPLEMENTARY ESTIMATES

JUNE 6, 1960

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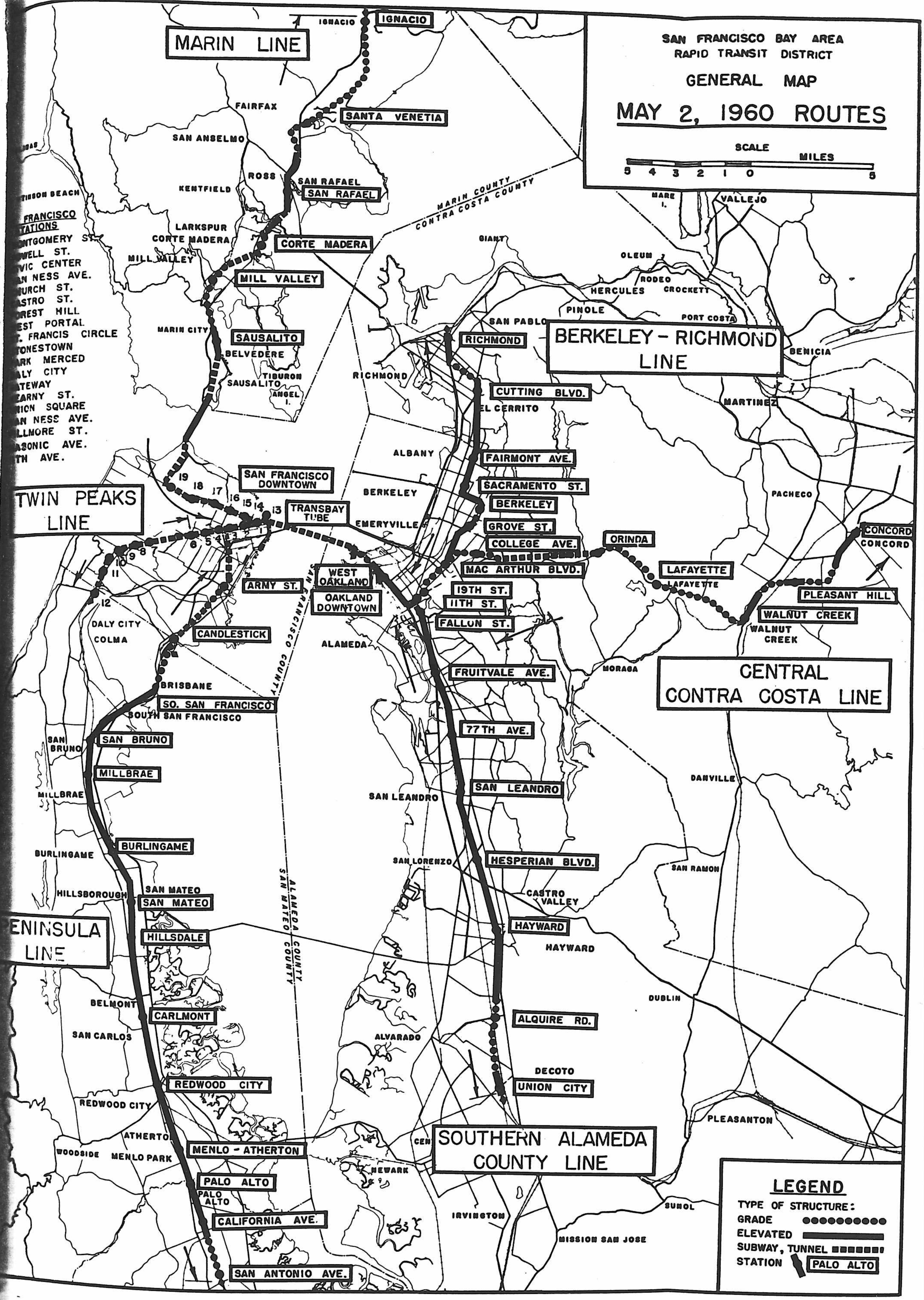
SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT
GENERAL MAP
MAY 2, 1960 ROUTES
SCALE
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5 4 3 2 1 0 5
MARIN LINE
IGNACIO
SANTA VENETIA
FAIRFAX
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LARKSPUR
CORTE MADERA
MILL VALLEY
MARIN CITY
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BURLINGAME
HILLSBOROUGH
SAN MATEO
HILLSDALE
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BENICIA
MARTINEZ
SAN PABLO
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BERKELEY - RICHMOND LINE
CUTTING BLVD.
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GROVE ST.
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UNION CITY
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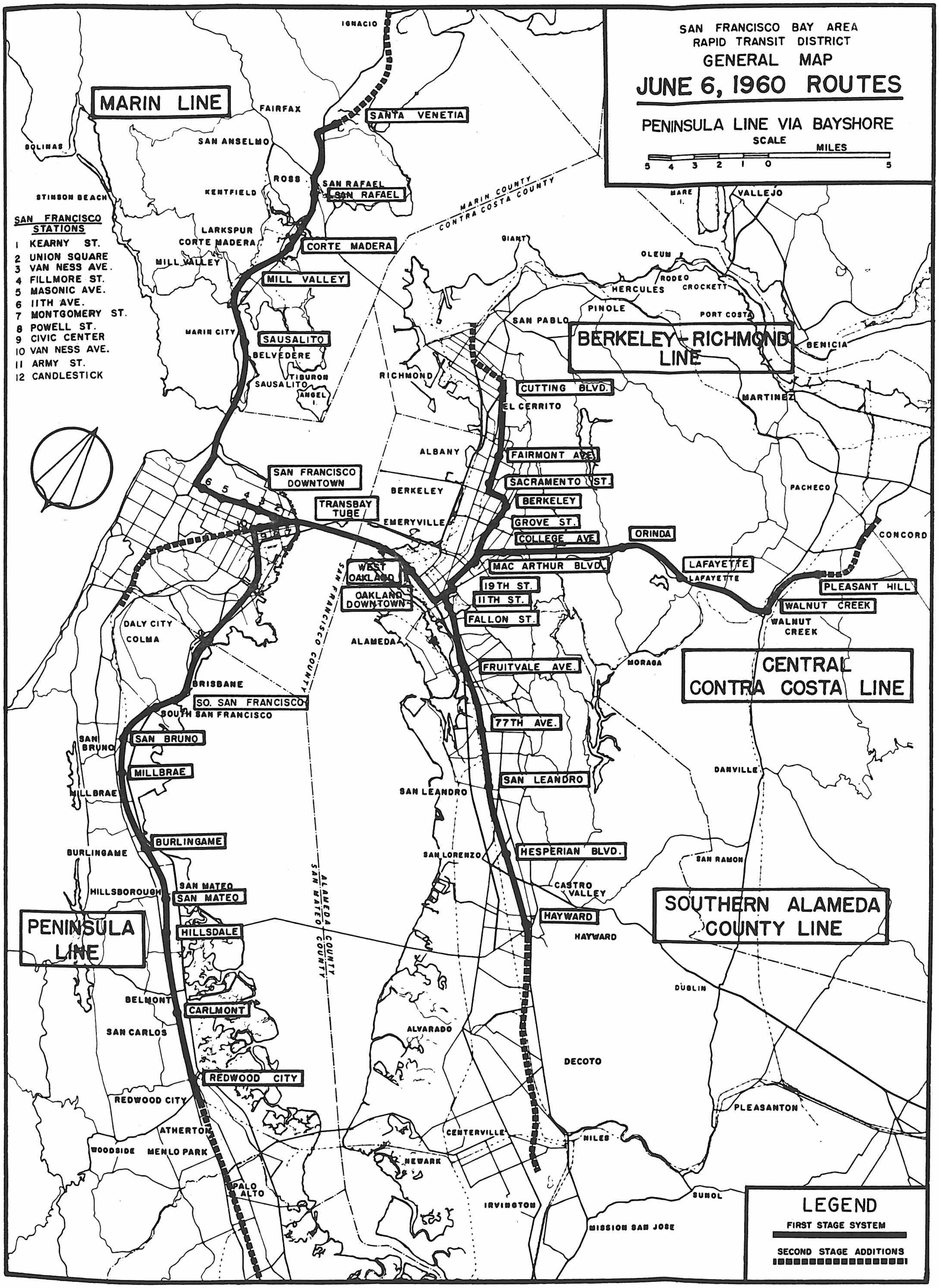
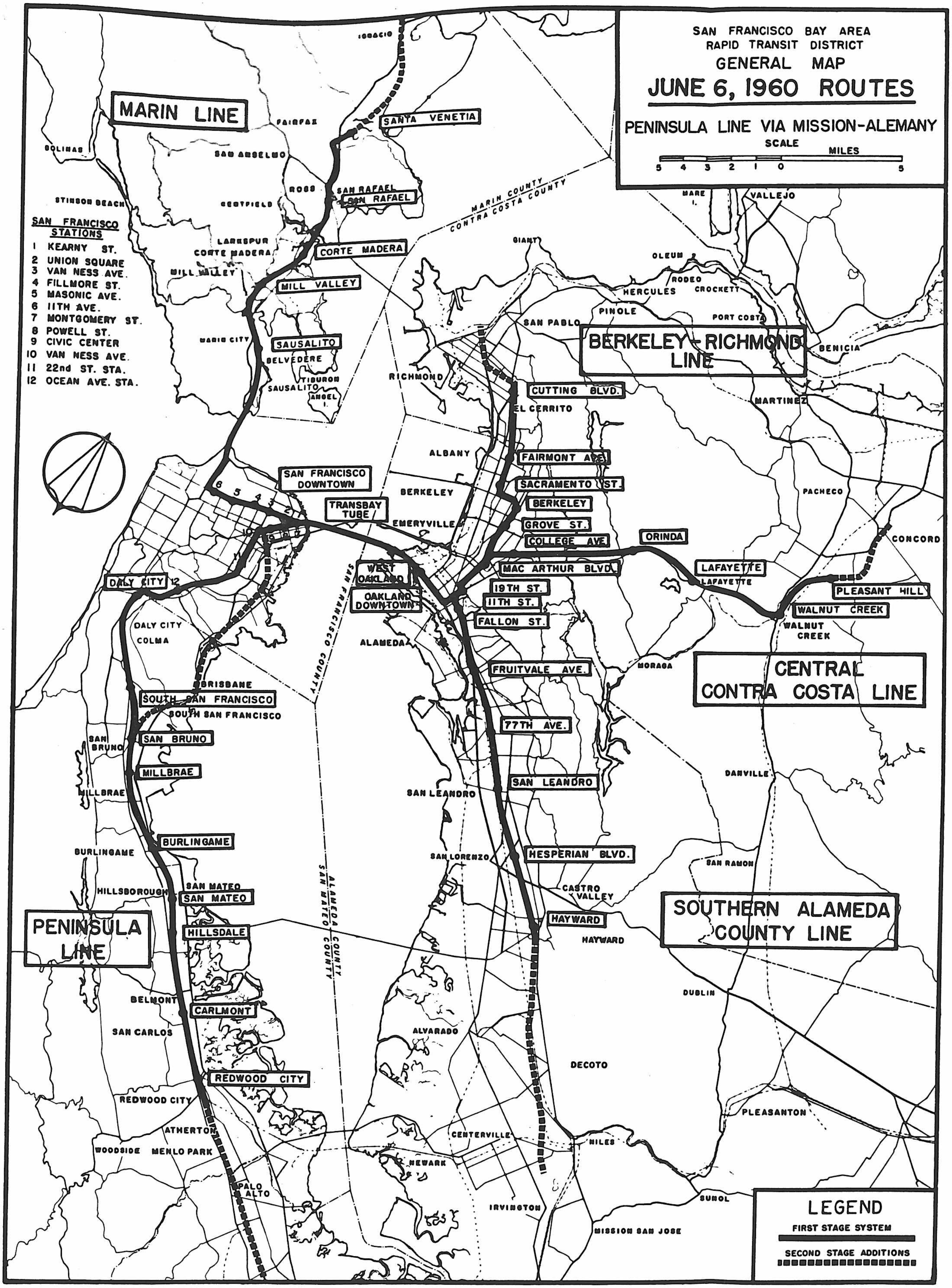
NEWARK
IRVINGTON
MISSION SAN JOSE
SOUTHERN ALAMEDA COUNTY LINE
ORINDA
MORAGA
LAFAYETTE
WALNUT CREEK
PLEASANT HILL
CONCORD
PACHECO
CENTRAL CONTRA COSTA LINE
DANVILLE
SAN RAMON
DUBLIN
PLEASANTON
SUNOL
LEGEND
TYPE OF STRUCTURE:
GRADE
ELEVATED
SUBWAY, TUNNEL
STATION
PALO ALTO



SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT
GENERAL MAP
JUNE 6, 1960 ROUTES
PENINSULA LINE VIA BAYSHORE

SAN FRANCISCO STATIONS
1 KEARNY ST.
2 UNION SQUARE
3 VAN NESS AVE.
4 FILLMORE ST.
5 MASONIC AVE.
6 11TH AVE.
7 MONTGOMERY ST.
8 POWELL ST.
9 CIVIC CENTER
10 VAN NESS AVE.
11 ARMY ST.
12 CANDLESTICK

LEGEND
FIRST STAGE SYSTEM
SECOND STAGE ADDITIONS


SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT
GENERAL MAP
JUNE 6, 1960 ROUTES
PENINSULA LINE VIA MISSION-ALEMANY
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WOODSIDE
MENLO PARK
CENTERVILLE
NILES
NEWARK
PALO ALTO
SUNOL
IRVINGTON
MISSION SAN JOSE
LEGEND
FIRST STAGE SYSTEM
SECOND STAGE ADDITIONS

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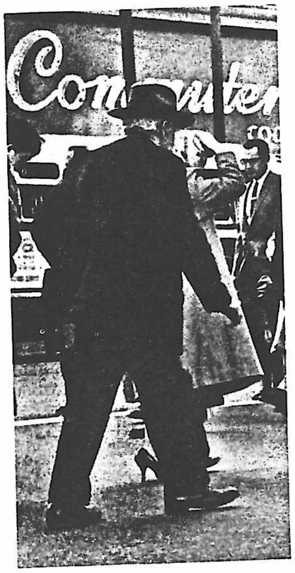

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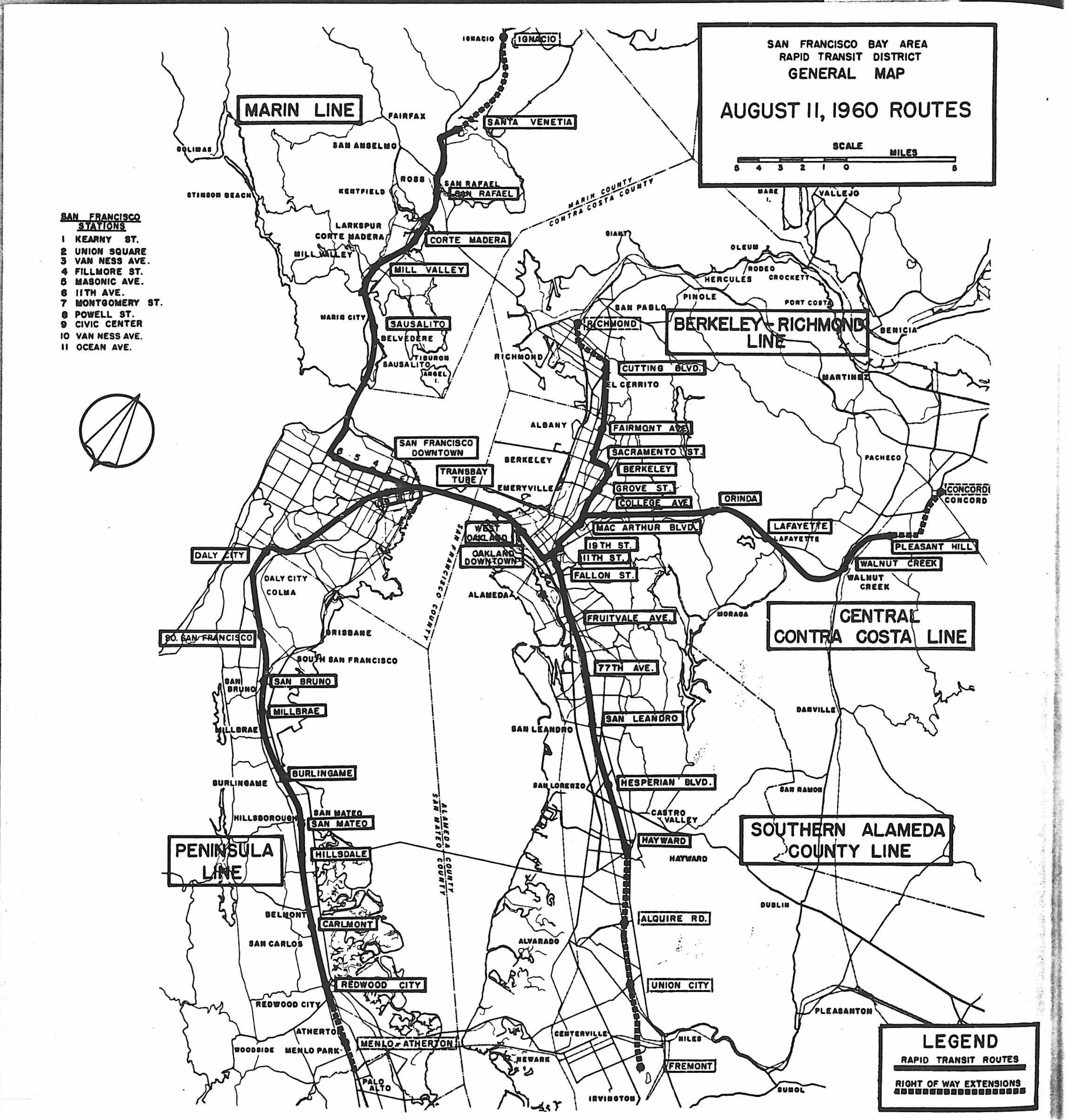
SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT
GENERAL MAP
AUGUST 11, 1960 ROUTES
SCALE
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5 4 3 2 1 0 5
SAN FRANCISCO STATIONS
1 KEARNY ST.
2 UNION SQUARE
3 VAN NESS AVE.
4 FILLMORE ST.
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9 CIVIC CENTER
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11 OCEAN AVE.
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ALVARADO
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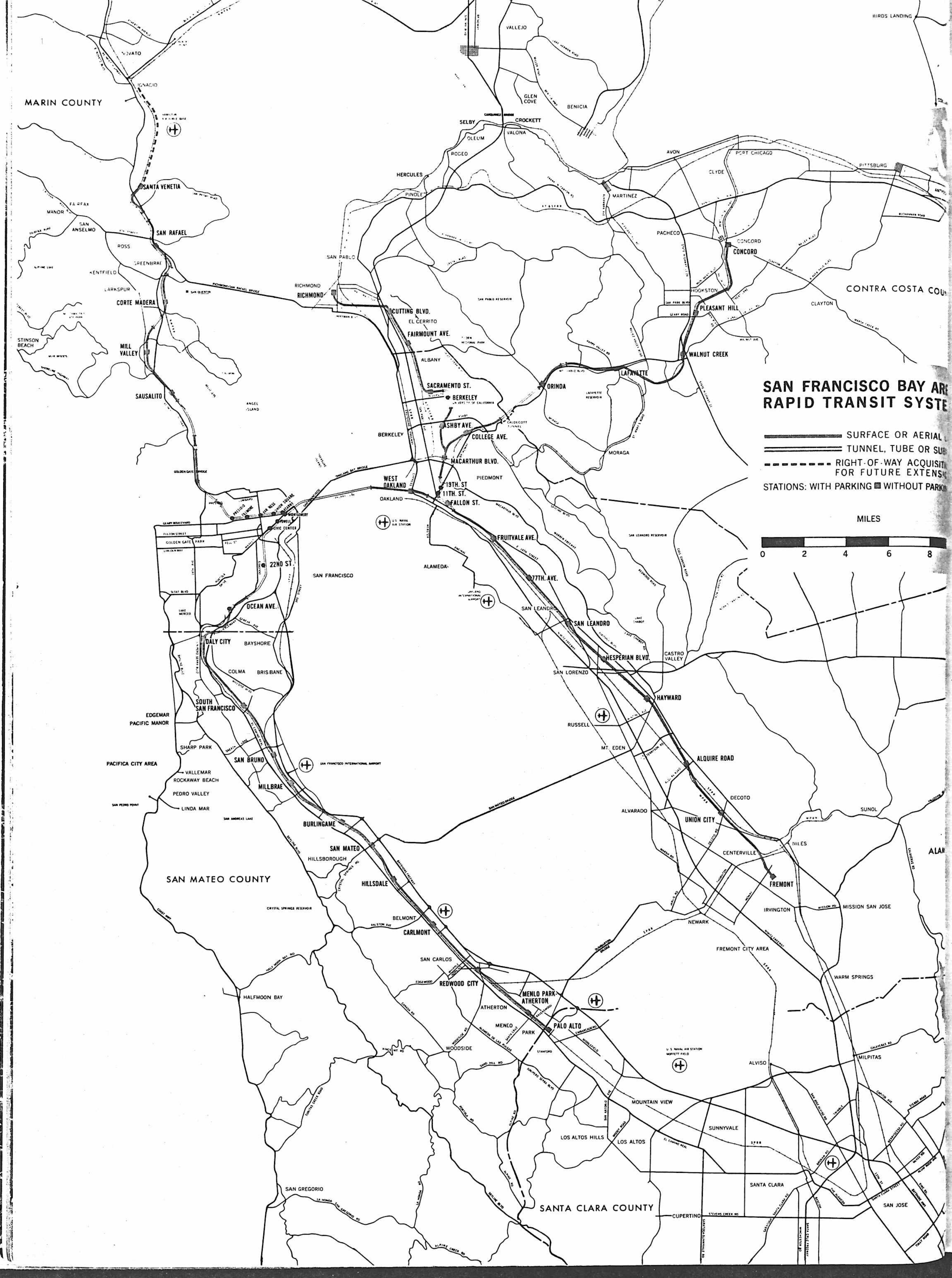
CENTERVILLE
NEWARK
NILES
FREMONT
IRVINGTON
SUNOL
PLEASANTON
LEGEND
RAPID TRANSIT ROUTES
RIGHT OF WAY EXTENSIONS

ENGINEERING REPORT TO
THE SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT

JUNE 1961

THE REPORT

PARSONS BRINCKERHOFF • TUDOR • BECHTEL, ENGINEERS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COLLEGE AVE.
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OAKLAND
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11TH. ST.
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FRUITVALE AVE.
ALAMEDA
77TH. AVE.
SAN LEANDRO
HESPERIAN BLVD.
CASTRO VALLEY
SAN LORENZO
HAYWARD
RUSSELL
MT. EDEN
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DECOTO
ALVARADO
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SUNOL
NILES
CENTERVILLE
FREMONT
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MISSION SAN JOSE
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FREMONT CITY AREA
WARM SPRINGS
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MONTGOMERY
POWELL
CIVIC CENTER
22ND ST.
SAN FRANCISCO
OCEAN AVE.
DALY CITY
BAYSHORE
COLMA
BRISBANE
SOUTH SAN FRANCISCO
EDGEMAR
PACIFIC MANOR
SHARP PARK
PACIFICA CITY AREA
VALLEMAR
ROCKAWAY BEACH
PEDRO VALLEY
LINDA MAR
SAN BRUNO
MILLBRAE
BURLINGAME
SAN MATEO
HILLSBOROUGH
SAN MATEO COUNTY
HILLSDALE
BELMONT
CARLMONT
SAN CARLOS
REDWOOD CITY
MENLO PARK-ATHERTON
ATHERTON
MENLO PARK
PALO ALTO
STANFORD
WOODSIDE
HALFMOON BAY
ALVISO
MILPITAS
MOUNTAIN VIEW
SUNNYVALE
LOS ALTOS HILLS
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SANTA CLARA
SAN JOSE
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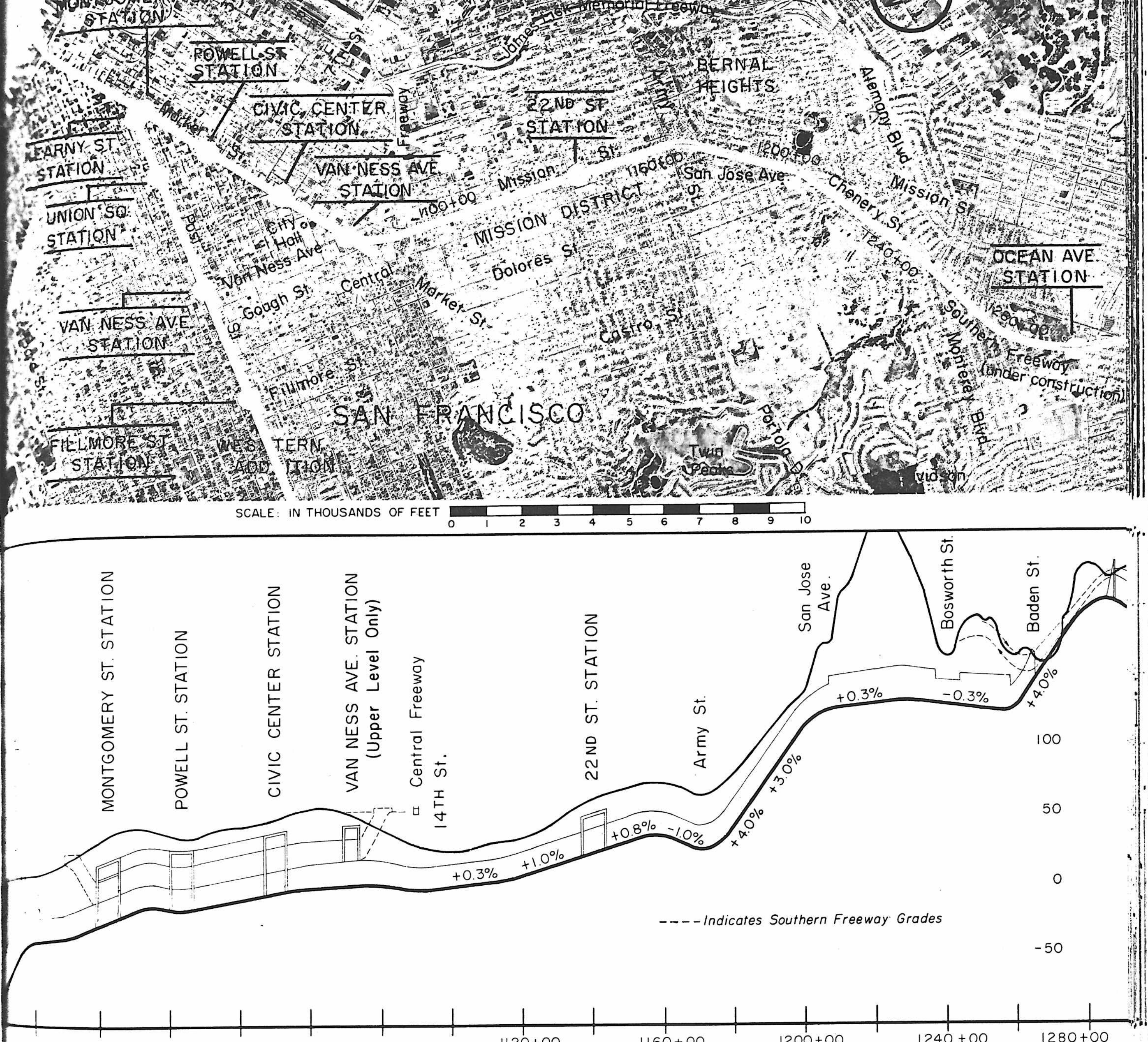
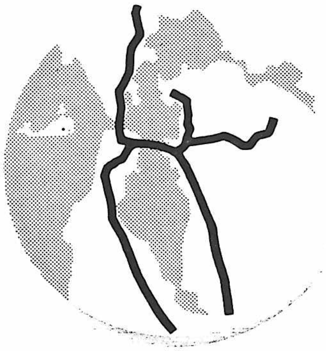


SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT

PLATE 2



PENINSULA LINE

STATION 1097+00 TO STATION 1240+00

INDICATES AREA SHOWN BY THIS PLATE

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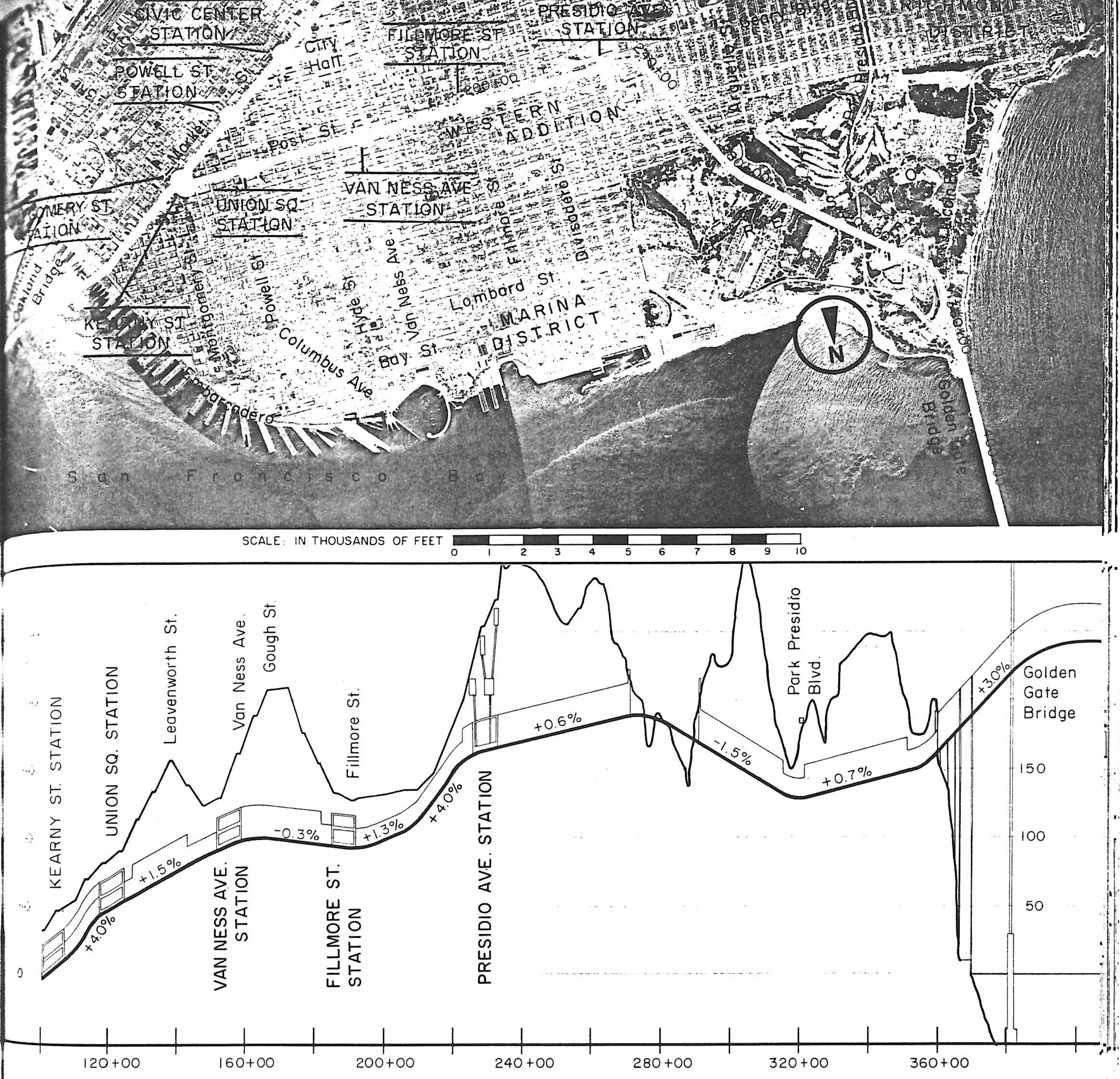
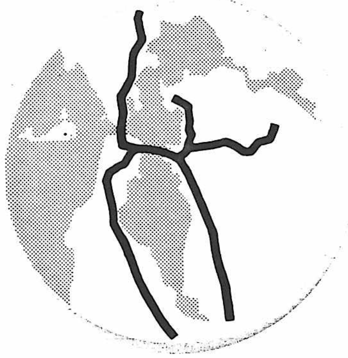


SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT



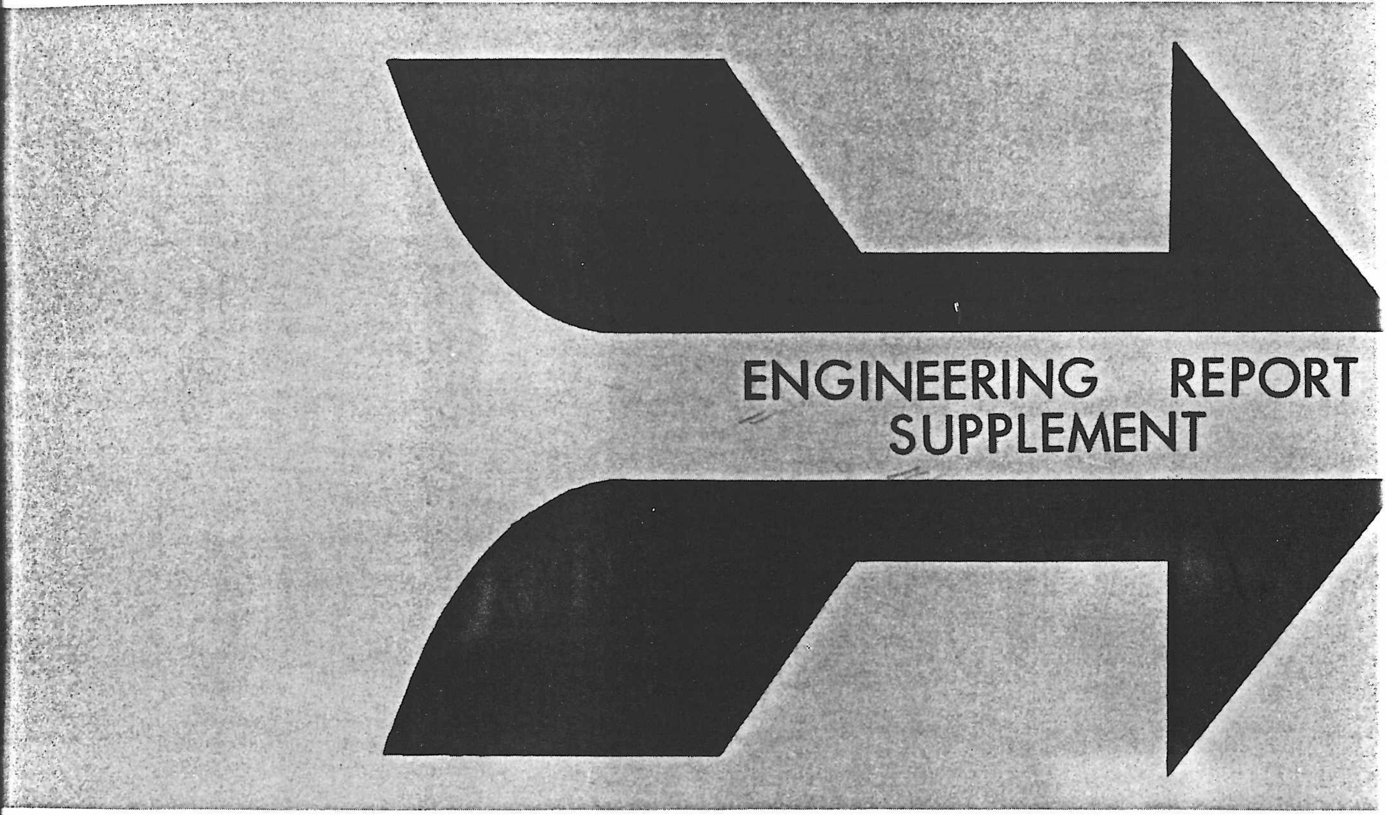
MARIN LINE

PLATE 9

STATION 174+00 TO STATION 360+00

▭ INDICATES AREA SHOWN BY THIS PLATE

PARSONS BRINCKERHOFF · TUDOR · BECHTEL, ENGINEERS



ENGINEERING REPORT SUPPLEMENT

RAPID TRANSIT FOR THE SAN FRANCISCO BAY AREA

PARSONS BRINCKERHOFF • TUDOR • BECHTEL

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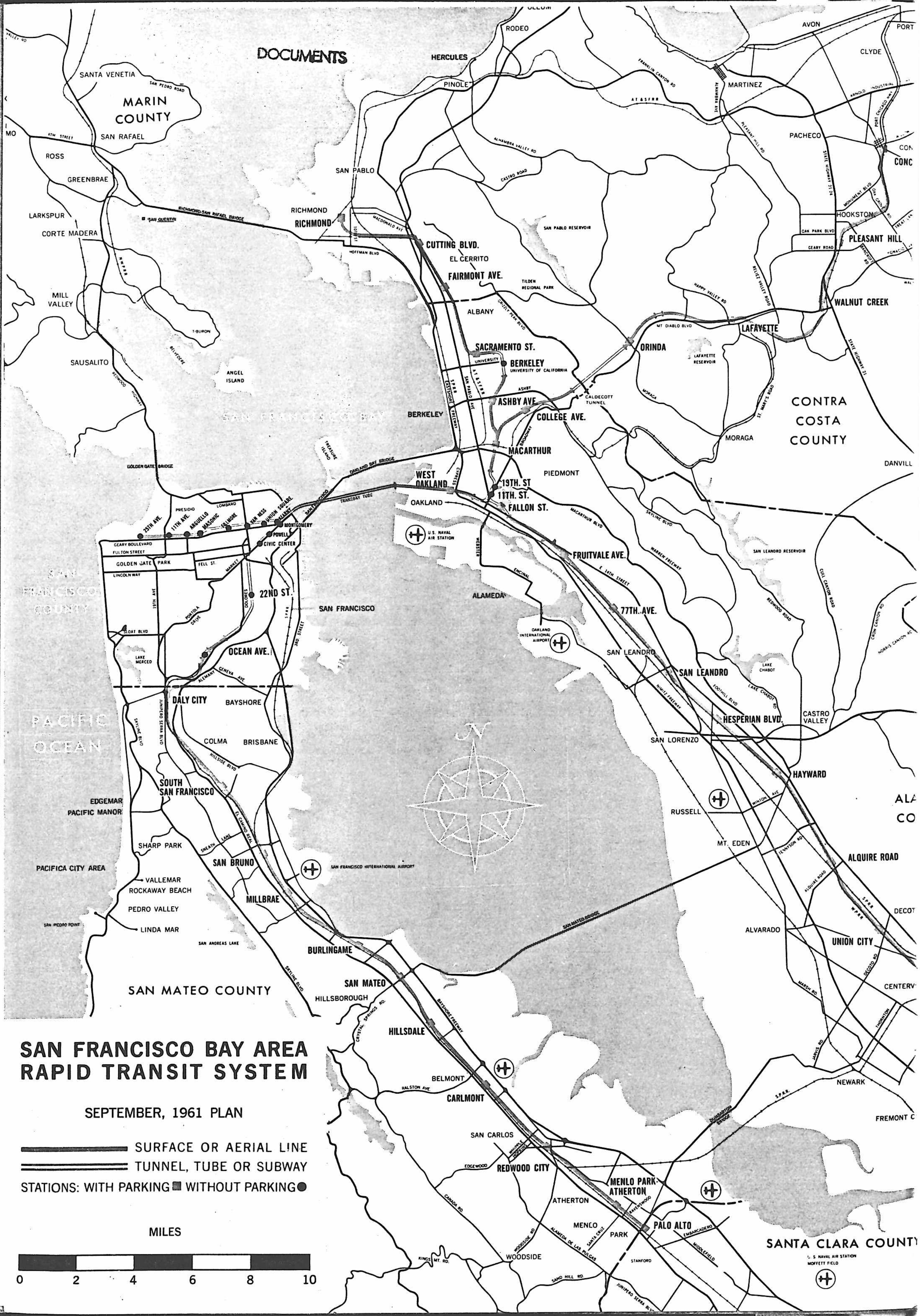


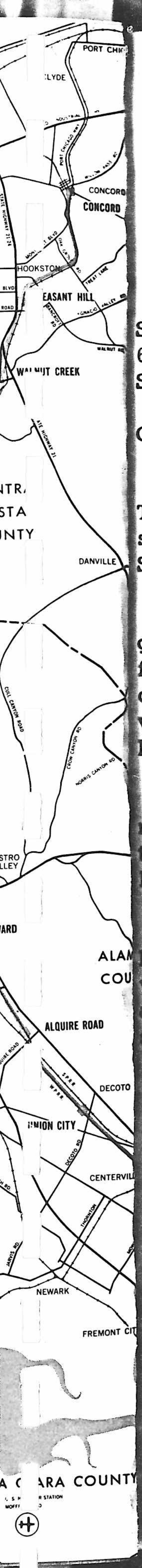
SAN FRANCISCO BAY AREA RAPID TRANSIT SYSTEM

SEPTEMBER, 1961 PLAN

SURFACE OR AERIAL LINE

TUNNEL, TUBE OR SUBWAY

STATIONS: WITH PARKING ▨ WITHOUT PARKING ●



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PARSONS BRINCKERHOFF — TUDOR — BECHTEL
General Engineering Consultants To
San Francisco Bay Area Rapid Transit District
833 Market Street
San Francisco

October 10, 1961

San Francisco Bay Area Rapid Transit District
628 Flood Building
San Francisco, California

Gentlemen:

Under date of June 20, 1961, we submitted our Engineering Report, "Rapid Transit for the San Francisco Bay Area", which presents a comprehensive rapid transit system for the five counties of Alameda, Contra Costa, Marin, San Francisco, and San Mateo.

Since the possible exclusion of Marin County has arisen due to some disagreement with the conclusion that operation of trains on the Golden Gate Bridge is feasible, you directed us to study and prepare this supplementary report on a four-county system excluding Marin County. It is our earnest hope, however, that a way will be found to resolve the problem of crossing the Golden Gate Bridge, keeping Marin County in the District plan.

This report describes the major differences between the two systems and resummarizes the resulting estimates and conclusions. Complete understanding of the four-county system and all its appurtenant features requires study of both the Engineering Report and this supplementary report.

The original five-county plan has been modifed to eliminate facilities in Marin County, leaving the four remaining counties with no less service than previously planned. The four-county system results in lower capital cost and requires a shorter period of construction. Like the five-county system, it too will earn sufficient revenues to pay operating expenses and debt service on rolling stock.

Revised plans and estimates for the four-county system are presented herein.

Very truly yours,

PARSONS BRINCKERHOFF-TUDOR-BECHTEL

Walter S. Douglas
Ralph A. Tudor
John R. Kiely

Parsons, Brinckerhoff
Quade & Douglas
165 - Broadway
New York - 6 - N. Y.

Tudor Engineering Co.
595 Mission Street
San Francisco - 5 - Cal.

Bechtel Corporation
220 Bush Street
San Francisco - 4 - Cal.

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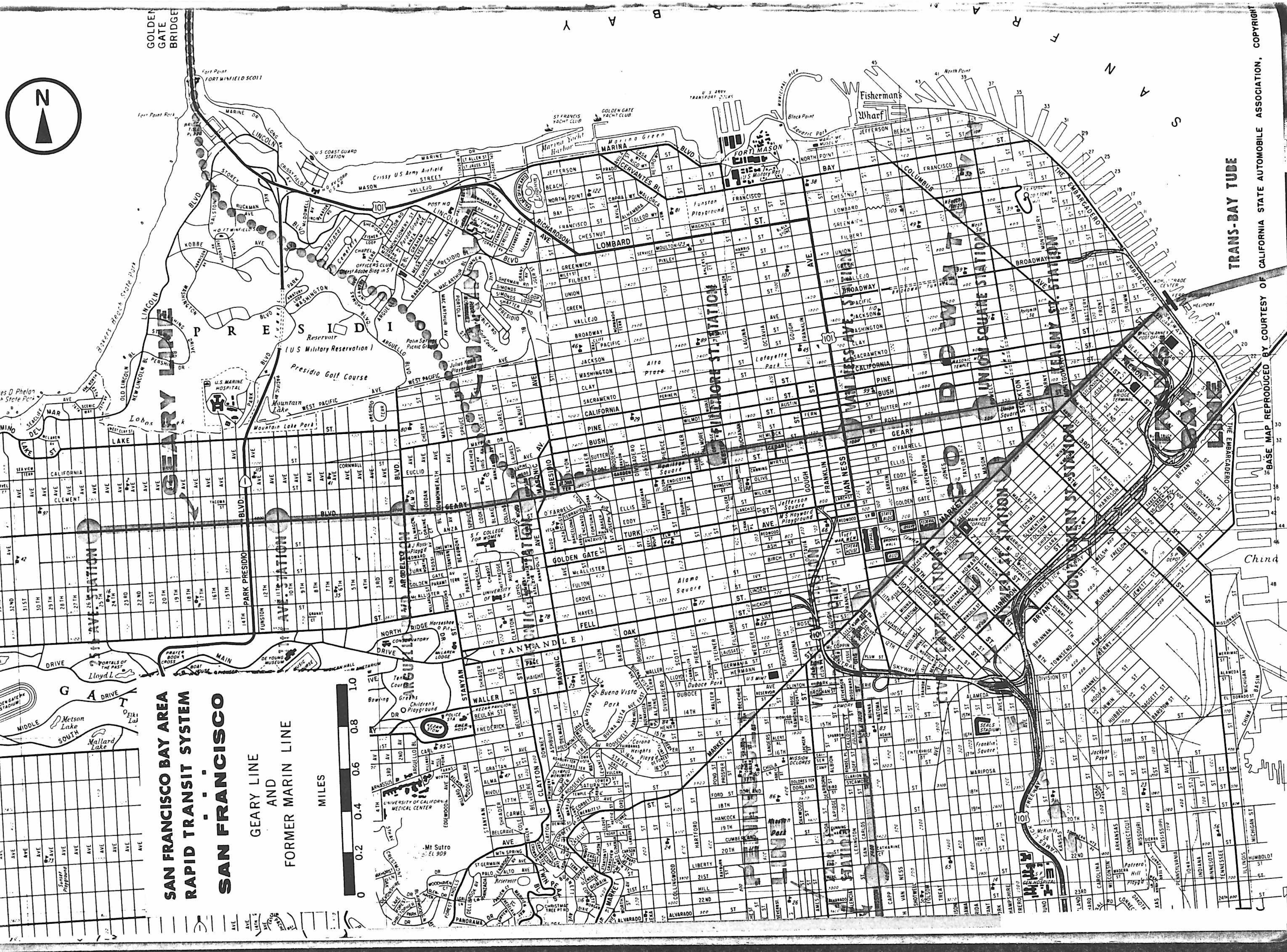

SAN FRANCISCO BAY AREA RAPID TRANSIT SYSTEM

SAN FRANCISCO

GEARY LINE
AND
FORMER MARIN LINE

MILES

BASE MAP REPRODUCED BY COURTESY OF CALIFORNIA STATE AUTOMOBILE ASSOCIATION, COPYRIGHT

THE COMPOSITE REPORT
BAY AREA RAPID TRANSIT
MAY 1962

Reports submitted to the San Francisco Bay Area Rapid Transit District describing the engineering, financial and economic phases of a rapid transit plan for Alameda, Contra Costa and San Francisco Counties.

by

PARSONS BRINCKERHOFF-TUDOR-BECHTEL
General Engineering Consultants

SMITH, BARNEY & CO.
Financial Consultant

STONE & YOUNGBERG
Financial Advisor

VAN BEUREN STANBERY
Economic Consultant

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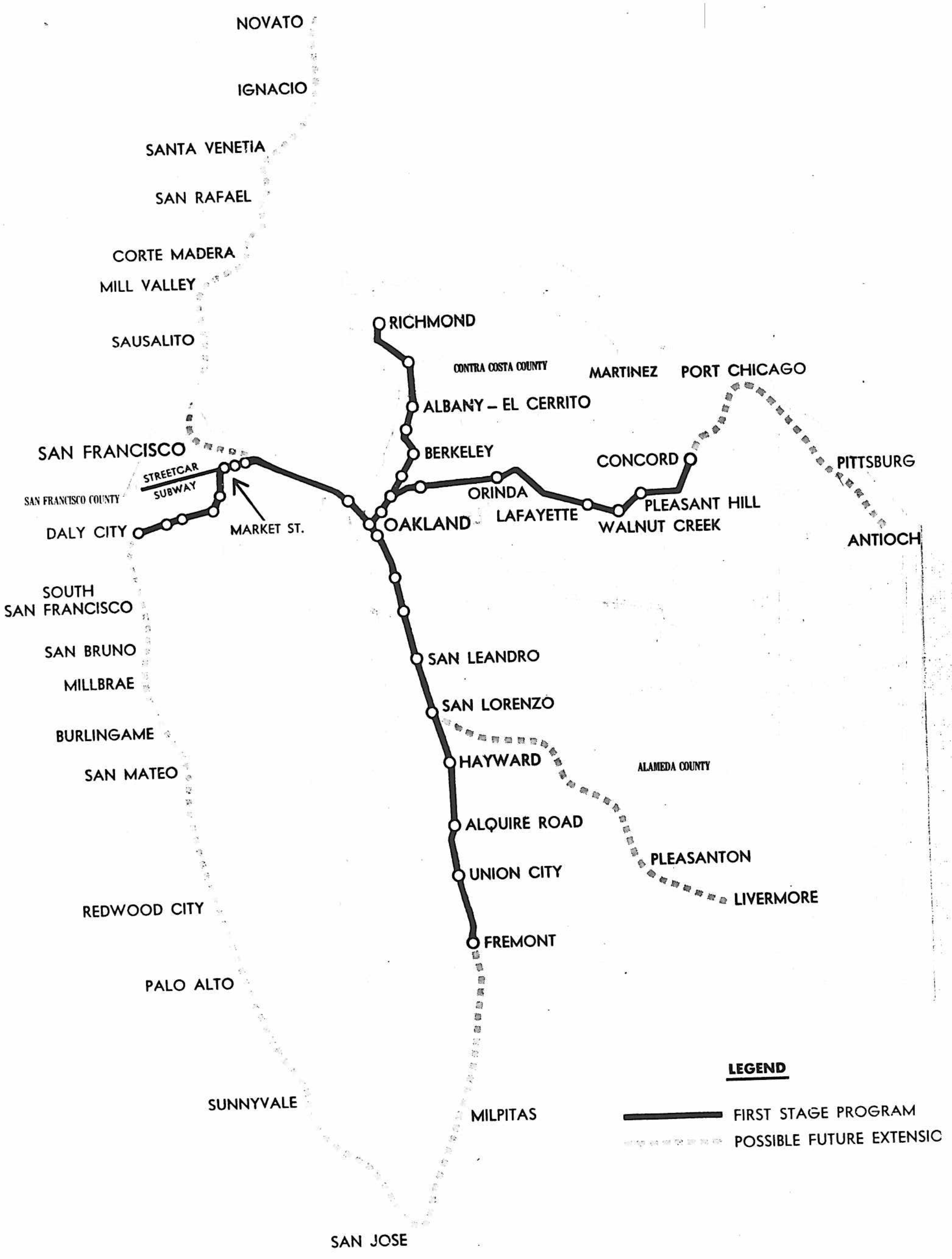
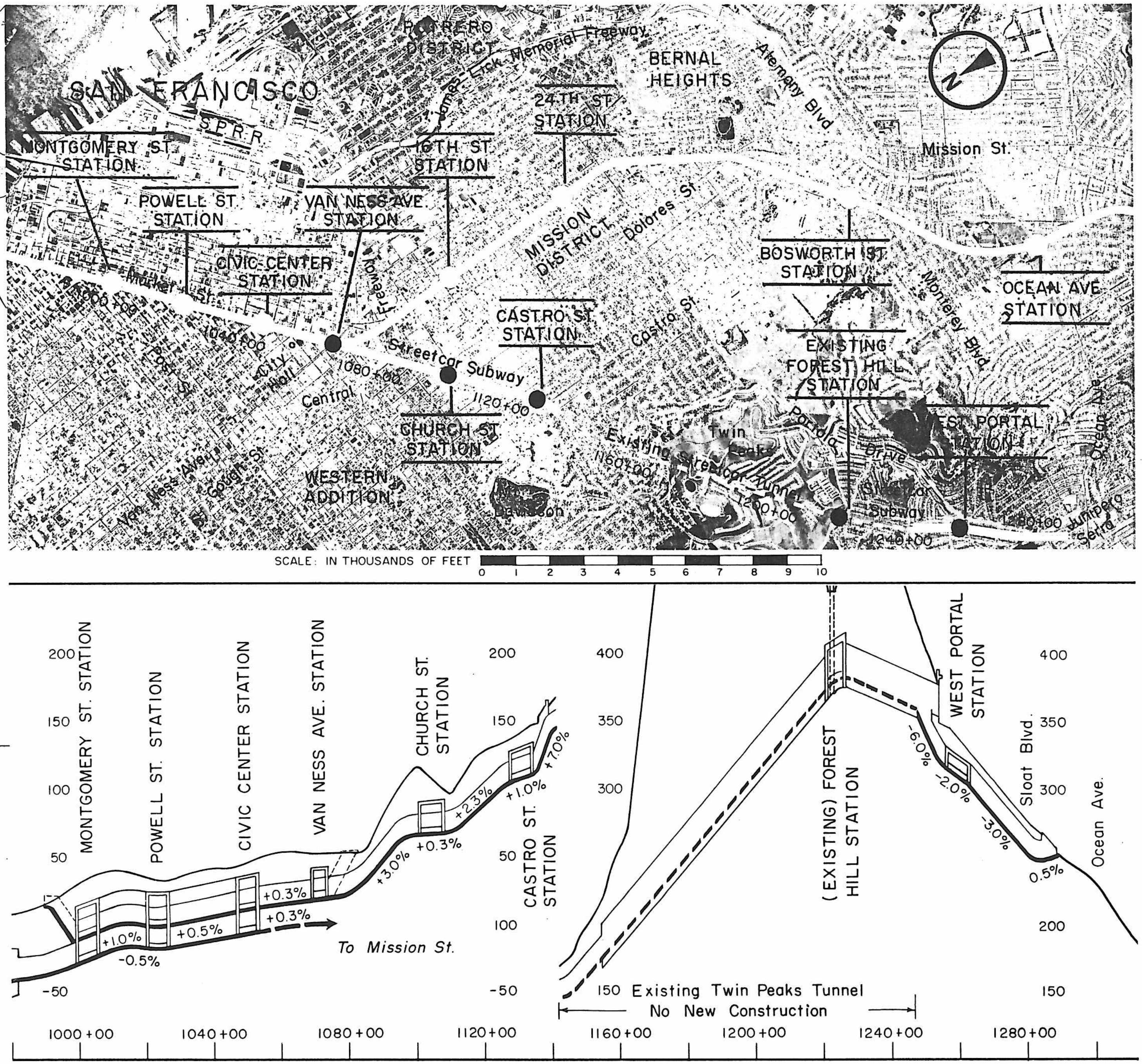


PLATE 1, SAN FRANCISCO DOWNTOWN (LEFT) AND TWIN PEAKS LINE (RIGHT), SEE TEXT P.



PARSONS BRINCKERHOFF-TUDOR-BECHTEL, ENGINEERS

supported on steel wheels running on con
rails and operated by automatic train con

The adoption of this transportation
basis for the estimates in this report does
continuing analysis and possibly ultimate
any different or untraditional method. In
the potential advantages and disadvanta
methods of rapid transit, comparison can
this modern proven system. Any other tr
to be adopted should serve as well or bette
be of equal or less cost.

The prototype car is 67 feet, 3 inches l
5 inches wide; and seats 76 passengers. T
weight of the car is under 800 pounds
achieve the required rates of acceleratio
self-propelled. Power is supplied by thir
tric motors driving each of the four axle
of the sliding type, and the windows are
sealed. The interior as well as exterior a
the rapid transit car is attractive. Suitab
and cooling and heating, freedom from
low noise level are necessary for passe
and satisfaction. Smooth riding qualities

In addition the vehicle is safe to pa
employees, and requires the minimum ou
tal costs of way and equipment and for co
ing and maintaining the system.

POWER AND PROPULSION

Numerous methods of propulsion and p
have been studied and evaluated in con
the studies of various transit methods. I
for a rapid transit system is usually direct
trical energy purchased as alternating cu
rectified to direct current. Operation of
ways and long tunnels precludes the use
diesel powered equipment producing no
While some potential does exist for new
es in the long-range future, the use of b
electric energy is still the most practical,
economical method for today's applicati

Three main types of electric motors
teristics more or less suited to traction
The polyphase induction motor is an e
ged, low-maintenance, and low-cost m
significant advantage that three-phase al
rent could be utilized directly without th
providing rectifying equipment to conve
to direct current. This motor, however,
a constant-speed machine, requiring add